Run II Upgrades
DOE mini-review

September 8, 2004

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Contents

- Introduction:
  - The Run II Upgrade Plan and Resource-Loaded Schedule
- Version 3
  - Major changes from v2 (Feb DOE Review)
- Recommendations Scorecard from Feb DOE Review
- Context for the next talks

Goal: maximize the integrated luminosity delivered

- Peak luminosity

$$L = \frac{3\gamma f_0}{\beta^*}(BN_p)\left(\frac{N_p}{\varepsilon_p}\right)\frac{F\left(\beta^*, \theta_{x,y}, \varepsilon_{p,\bar{p}}, \sigma^L_{p,\bar{p}}\right)}{\left(1+\varepsilon_{\bar{p}}/\varepsilon_p\right)}$$

Emittances ε_p, ε_{pbar}, form factor F, β^* provide some gains

But major improvements from bunch intensities

- especially total number of pbars BN_{pbar},
- proton brightness (N_p/ε_p) is constrained by beam-beam tune shift

- Luminosity lifetime (tunes, beam-beam interactions)
- Reliable operation – an essential component, major gains in the last year

Address all via *operational improvements* and *upgrade projects*

Run II Upgrade Plan - RLS

The Run II Upgrade Plan is dynamic

- via built-in scope decision points
- scope/strategy updates from operations or project R&D

Emphasis

- Increase pbar production, stack rate and size
  - Slip stacking: double intensity on pbar production target
  - Pbar acceptance upgrade
  - Stacking rate and stack size (stacktail, Recycler, e-cooling)
- Upgrade Tevatron for higher bunch intensities
  - Helix
  - R&D on active beam-beam compensation

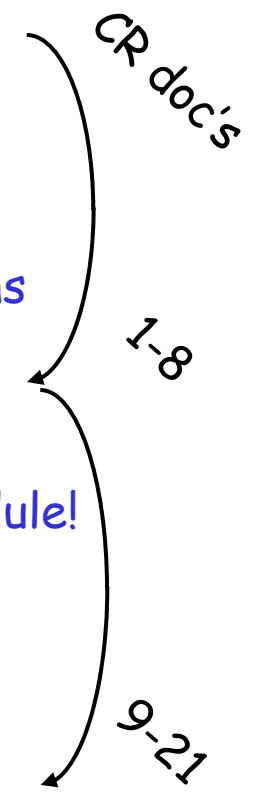
Also

- Many significant instrumentation upgrades (BPMs, BLMs, IPM…), alignment (Tevatron), reliability improvements (Tev Abort System…), and vulnerabilities (Linac tubes, Tev stands…)

WBS captures all long-term work planned for Run II

v1→v2→v3

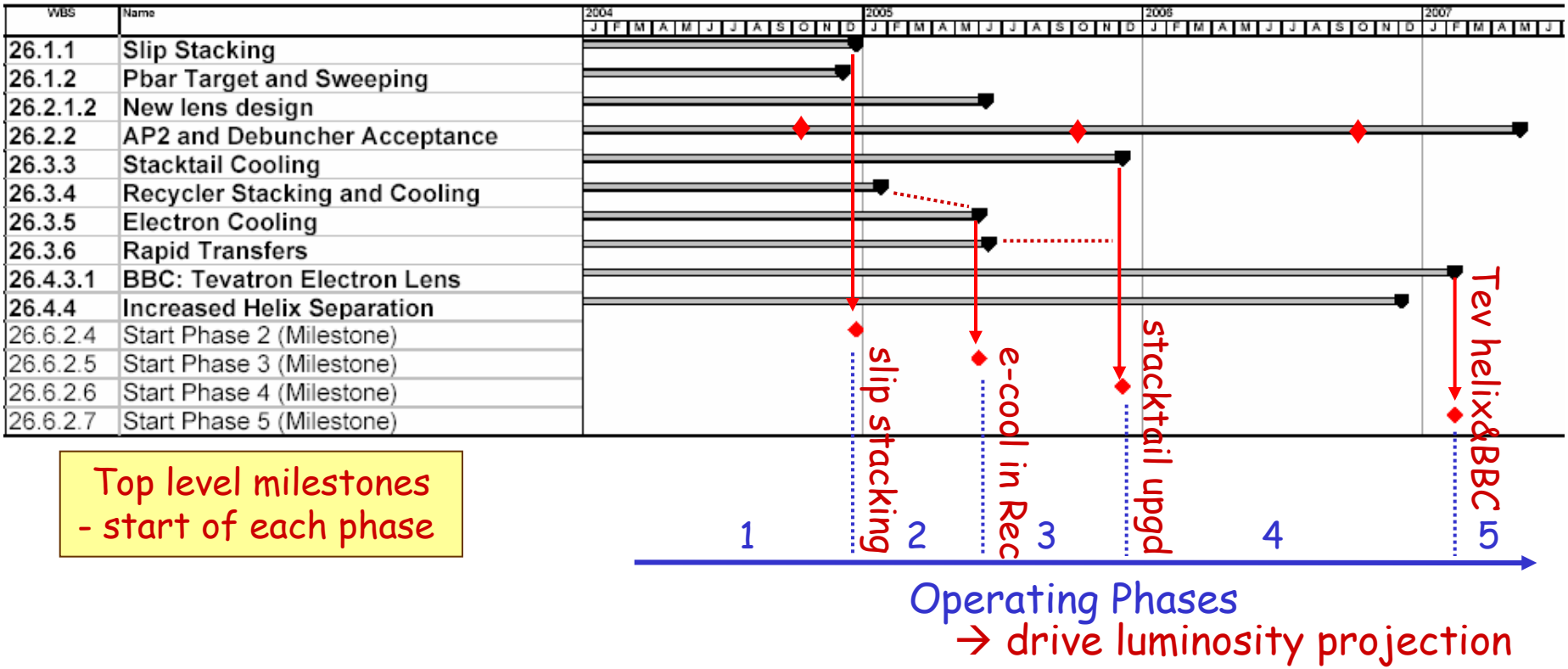
- V1 (July 03)
  - July 03 DOE Review
  - Guesstimate for Recycler and Electron Cooling
  - Scheduled technical reviews and scope decisions
  - Developed Operating Phases, and Design and Base projections
- V2 (Feb 04)
  - Feb 04 DOE
  - Recycler plan detailed - fitted within the place-holder schedule!
  - Many scope decisions made
  - More schedule and resource detail
  - Design, Base and Fall-back scenario analysis
- V3 (July 04)
  - Schedule changes – re-optimize strategy to compensate
  - Minor scope changes and ADD new instrumentation subprojects within budget guidance
  - No significant change in long-term Design projection, Fall-back more robust



Subprojects and Operating Phases

V2: Feb 04 Review

WBS	Name
26.1.1	Slip Stacking
26.1.2	Pbar Target and Sweeping
26.2.1.2	New lens design
26.2.2	AP2 and Debuncher Acceptance
26.3.3	Stacktail Cooling
26.3.4	Recycler Stacking and Cooling
26.3.5	Electron Cooling
26.3.6	Rapid Transfers
26.4.3.1	BBC: Tevatron Electron Lens
26.4.4	Increased Helix Separation
26.6.2.4	Start Phase 2 (Milestone)
26.6.2.5	Start Phase 3 (Milestone)
26.6.2.6	Start Phase 4 (Milestone)
26.6.2.7	Start Phase 5 (Milestone)

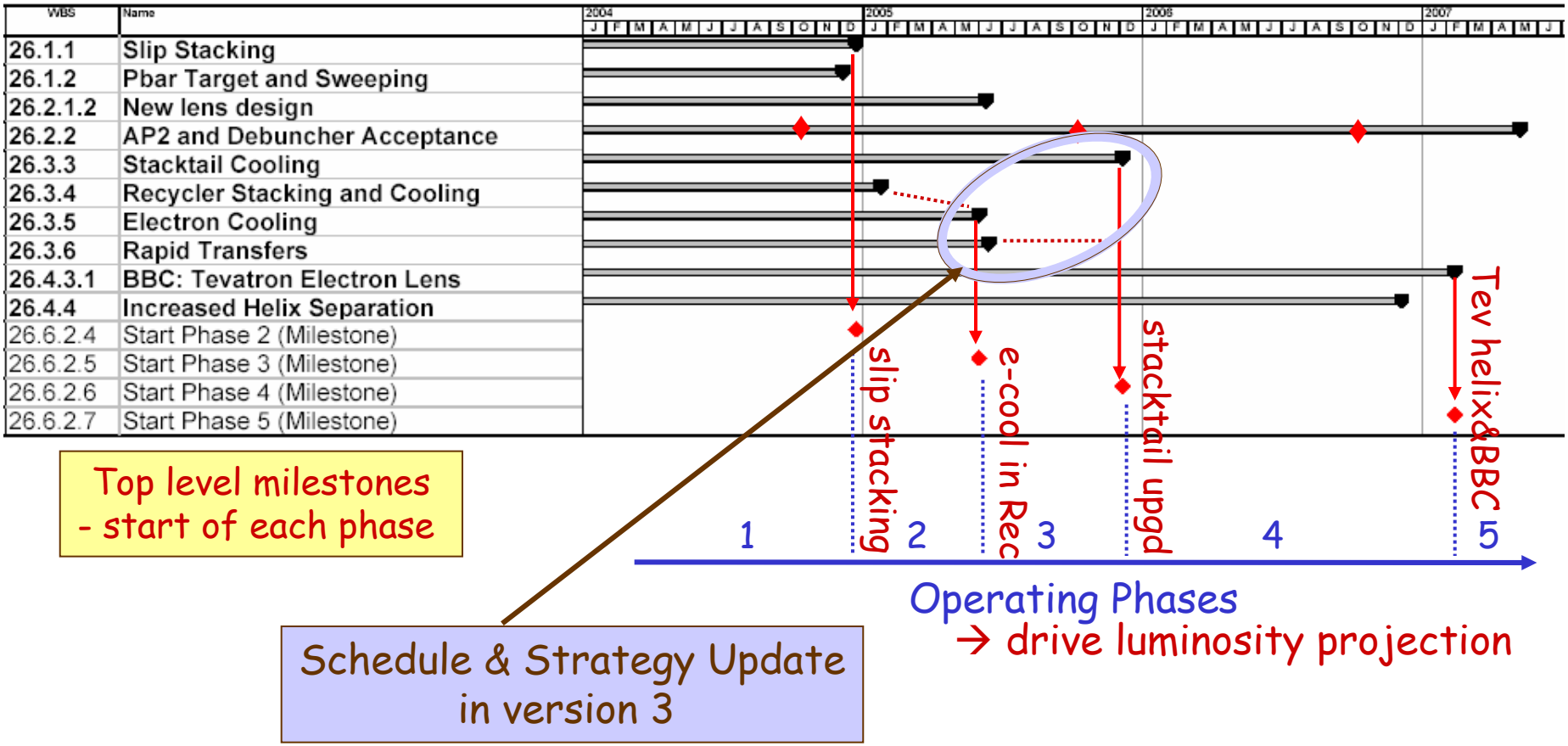


Top level milestones
- start of each phase

No internal schedule contingency in the RLS (intended for planning, not reporting)
Contingency at top level add ~3 months (Phase 2), 6 months each (other phases)

Subprojects and Operating Phases

V2: Feb 04 Review



Top level milestones
- start of each phase

Schedule & Strategy Update
in version 3

No internal schedule contingency in the RLS (for planning, not reporting)
Contingency at top level add ~3 months (Phase 2), 6 months each (other phases)

Class A Milestones: v2 and v3

Milestone	V2	V3
New target in operation	1/2/04	1/2/04
Review Recycler commissioning plan	2/9/04	3/1/04
Recycler commissioned for Electron cooling	6/1/04	6/1/04
Beam Sweeping ready	8/25/04	10/21/04
Initial AP2&DB improvements complete	11/22/04	11/22/04
New standard separators operational	10/25/04	12/16/04
Slip Stacking operational	12/23/04	12/23/04
Start Phase 2	**12/23/04**	**12/23/04**
New lens operational	6/10/05	8/25/05
Electron cooling of pbars demonstrated	**6/1/05**	**9/8/05**
Intermediate AP2&DB improvements complete	10/3/05	10/3/05
Rapid Transfers operational	6/14/05	10/31/05
Start Phase 3	**6/1/05**	**1/2/06**
Final AP2&DB improvements complete	10/2/06	10/2/06
Stacktail Upgrade: Bandwidth, operational	12/6/05	12/5/06
Start Phase 4	**12/6/05**	**12/5/06**
New helix operational	12/5/06	12/14/06
TEL system operational	2/12/07	2/12/07
Start Phase 5	**2/12/07**	**2/12/07**

demonstrate e-cooling

Phase 3 redefined: now includes interim stacktail upgd

stacktail bandwidth upgrade

Schedule and Strategy Update

- E-cooling
  - R&D program on e-beam completed successfully
  - now installing at Recycler – on plan
- Schedule slip 3 months vs V2
  - change to upgrade schedule, but NOT BAD for such a challenging R&D project
- Next: Commission electron cooling of pbars at Recycler
  - schedule uncertain, est demo of cooling by 05 shutdown, start in HEP by end 05
- Two recent technical reviews:
  - e-cool installation (7/27/04), and commissioning plan (8/10/04)
- Need operating experience with electron cooling before installing the bandwidth upgrade in the Stacktail
  - now scheduled for 06 shutdown

→ Mixed source operation (pbars from both Accumulator and Recycler) until e-cooling phased into operation – capitalize on improved reliability

→ Phased approach to the Stacktail Upgrade

Phased Approach

Stacktail

- Present stacktail
  - average ~ 10E10/hr, core <250E10 in the accumulator
- Tank move
  - ~30E10/hr (plus x2 margin), core ~ 40-60E10, transfer > hourly to Recycler
  - quick to implement and reverse
- Bandwidth upgrade
  - ~40E10/hr (x2 margin), core ~ 20-40E10, transfer ~ half-hourly
  - major shutdown to install and reverse

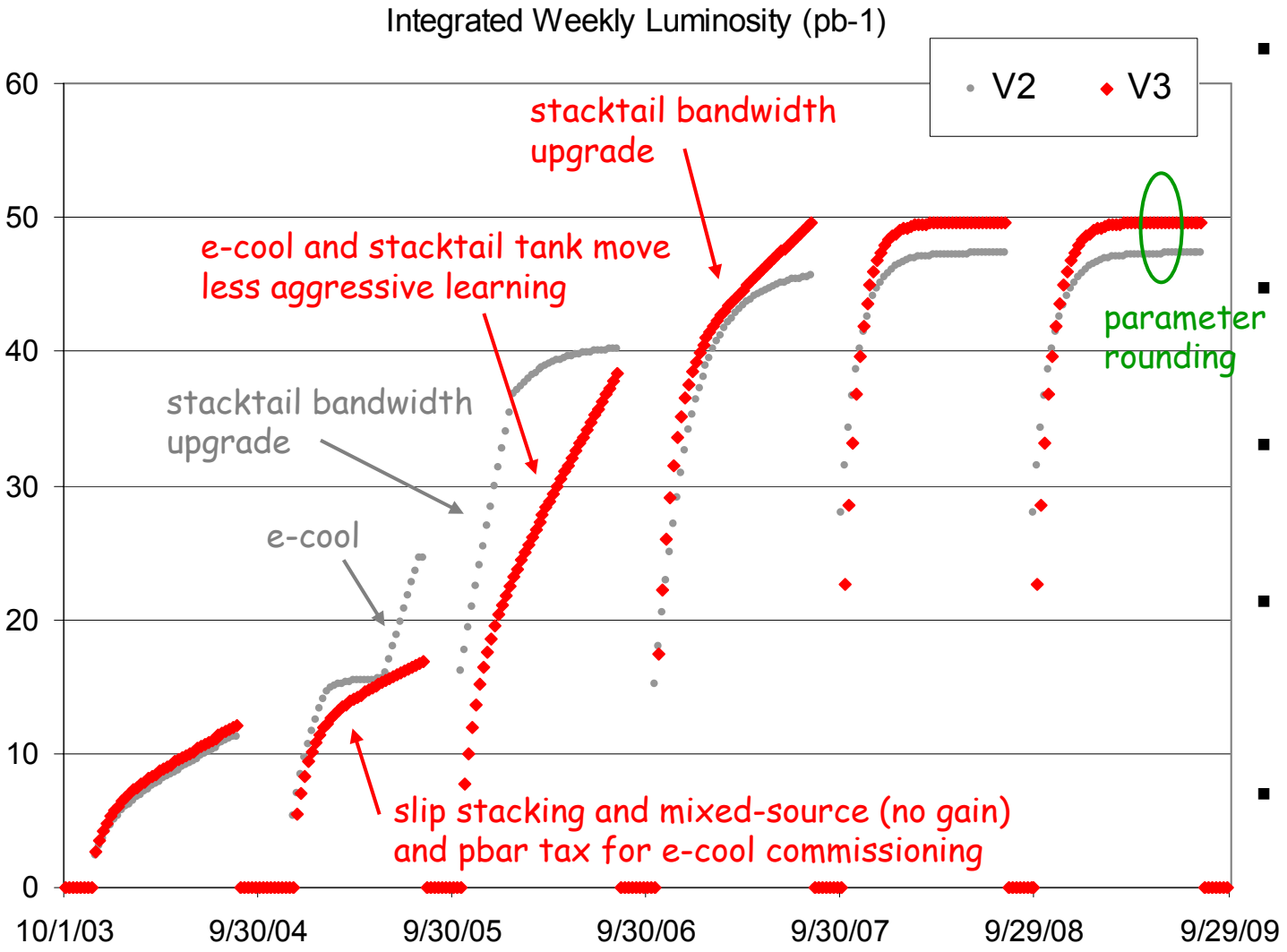
Acumulator → Recycler Transfers

- now: manual, proton tune-up like shot setup, takes < 1 hr
- Mar 05: MI injection dampers, AP1 ramped, no tune-up ~ 10min
- Dec 05: BPM upgrade → auto-feedback for next transfer ~ 2min

Sequence

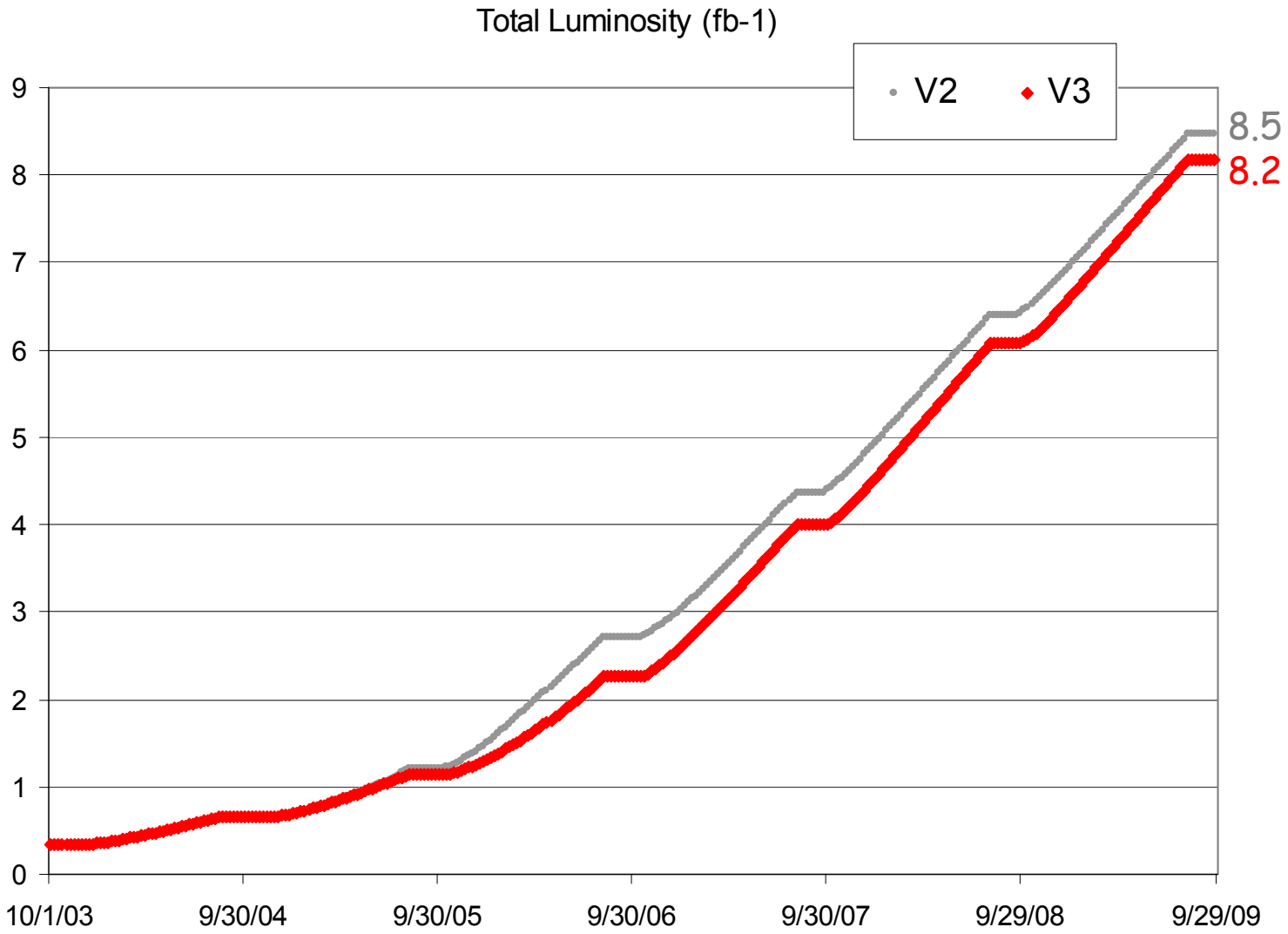
- mixed-source operation through 05
- end 05 (once electron cooling is operating in HEP): Tank move
- early 06: Bandwidth upgrade ready to install
- bandwidth upgrade installed summer 06 shutdown

Design Projection



- V3 schedule
- Mixed-source operation in 05, assumed to be break-even (conservative)
- Phased stacktail upgrade
- Pbar tax in FY05 (e-cool…)
- More conservative shutdown recovery and learning slope for each phase
- Parameters rounded (store length, HEP hrs)

Design Projection



V2 → V3 Cost Comparison

V2 and V3 M&S and SWF base estimates in $FY03 (not esc)

$K	M&S				SWF			
in FY03 $	Base	Cont		Total	Base	Cont		Total
V1	14,965	7,462	50%	**22,427**	18,194	9,706	53%	**27,900**
V2	**16,811**				**17,980**			
V3	**17,856**				**19,605**			

- Increase V3-V2 is $1,045K M&S and $1,625K SWF
- Includes new instrumentation projects (OTR, BLM upgrades)
- Base+contingency in V1 → the budget guidance - manage the work to within this guidance (see later talk)
- Current available contingency is 50% of remaining cost (see later talk)

V2→V3 Change Requests

Log# (#1-8 were v1→v2)

sched & strategy

9. Change in schedule and cost for electron cooling and the start of operating phase 3
10. Change in implementation and cost of the Accumulator Stacktail upgrade and operating phases 3 and 4
11. Change in scope of the Beam Sweeping subproject

new inst'n projects

12. Addition of subproject to build optical transition radiation detectors
13. Cost change for the helix/separator work plan
14. Reduction in scope of AP2 and Debuncher acceptance work plan
15. Cost re-estimate for the Tevatron Beam Loss Monitor (BLM) upgrade and addition of subprojects for Main Injector and Booster BLM systems
16. Reduction in scope for specific tasks in Recycler commissioning
17. Increase in cost for general alignment support during Shutdowns
18. Labor cost increase for Transfer-line BPM upgrade project
19. Labor cost increase for Tevatron BPM project
20. Labor cost increase for Tevatron Alignment in '04
21. Labor cost increase for the LINAC tubes project

The total cost change in these documents is $852K M&S and $1645K labor

Recommendations Score Card

- 26 recommendations from Feb DOE review
- Compiled in a "recommendations scorecard" – see handout
- Will not go through in detail here …

Status Summary →

- Many items were already on-going
- "In-process" recommendations will be carried out by next review

	Recommendation	Carried out	In Process	As recommended	Similar to Rec'n
Accelerator Physics	AP1		X		X
	AP2		X		X
Proton Source	PS1=AS3	X		X	
	PS2	X		X	
	PS3	X		X	
	PS4	X		X	
Antiproton Source	AS1	X		X	
	AS2=I1	X		X	
	AS3=PS1	X		X	
	AS4	X		X	
	AS5	X		X	
	AS6	X		X	
Tevatron	T1	X		X	
	T2		X	X	
	T3		X	X	
	T4		X		X
	T5		X		X
	T6		X	X	
	T7		X	X	
Instrumentation	I1=AS2		X	X	
	I2	X		X	
Cost Estimate	CE1	X		X	
Overall Management	OM1		X		X
	OM2=MP1	X		X	
Management Process	MP1=OM2	X		X	
Planning and Plans	PP1	X		X	
	PP2	X		X	
	PP3	X		X	
	PP4	X		X	

Next Talks

- Dave McGinnis
  - Operational improvements
  - Performance since Feb review > design projection
  - Mixed-source operation
  - Pbar stacking rate
- Pushpa Bhat
  - Excellent technical progress on the upgrade projects
  - Technical reviews
- Jeff Spalding
  - Schedule and cost report
  - Luminosity projection: fall-back scenario